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A review of the montane lacewing genus *Rapisma* McLachlan (Neuroptera, Ithonidae) from China, with description of two new species

Xingyue Liu[1]

1 *Department of Entomology, China Agricultural University, Beijing 100193, China*

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Corresponding author: *Xingyue Liu* (xingyue_liu@yahoo.com)

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Abstract

The genus *Rapisma* McLachlan, 1866 (Insecta: Neuroptera: Ithonidae) is a rare and poorly known lacewing group endemic to Asia. Here I present a revision of the *Rapisma* species from China, with description of two new species, namely *Rapisma changqingensis* **sp. n.** and *Rapisma chikuni* **sp. n.** The Chinese *Rapisma* now comprises five species that respectively belong to two monophyletic species groups. *Rapisma changqingensis* **sp. n.** represents the northernmost record of the genus, being distributed at the border of eastern Palaearctic and Oriental regions. Moreover, the homology of genital sclerites of *Rapisma* is also updated.

Key Words

Neuropterida
taxonomy
new species
Oriental region

Introduction

The genus *Rapisma* McLachlan, 1866 (commonly called montane lacewings) is one of the extremely rare groups of the holometabolous insect order Neuroptera. The adults of *Rapisma* are a kind of spectacular lacewings, with relatively large body-size and moth-like general appearance. They are characterized by the broad body, the head retracted under stout prothorax, the short antennae, and the broad wings, usually being greenish, yellowish or brownish, with complex venations (see detailed generic characters in the systematic section below). Previously, *Rapisma* was the single representative of the family Rapismatidae (Krüger 1922, Navás 1929), while it is recently assigned to Ithonidae sensu lato, which constitutes three former lacewing families, i.e. Ithonidae sensu stricto, Polystoechotidae and Rapismatidae (Winterton and Makarkin 2010). So far, *Rapisma* is the only extant ithonid genus that occurs in Asia, with distribution area primarily confined to the Oriental region, and it comprises 18 valid described species (Oswald 2017). However, 12 *Rapisma* species are known respectively from a single specimen, suggesting the rareness of this genus.

The most comprehensive study on *Rapisma* refers to Barnard (1981). Subsequently, Barnard and New (1985, 1986) and New (1985) provided considerable additional information on this genus. Nevertheless, *Rapisma* still needs further studies concerning its morphology, phylogeny and biology. First, the homologies of the genital sclerites in *Rapisma*, especially those of gonocoxites complex 9, 10 and 11, should be further interpreted basing on the homology assessment provided by Aspöck and Aspöck (2008). Second, the phylogeny as well as the historical biogeography of *Rapisma* is largely unknown. *Rapisma* was assigned into a monophyletic group together with *Adamsiana* Penny, 1996 from Central America, *Oliarces*

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Banks, 1908 from southwestern North America and two fossil genera (*Allorapisma* Makarkin & Archibald, 2009 from the early Eocene of U.S.A. and *Principiala* Makarkin & Menon, 2007 from the Lower Cretaceous of Brazil and England) based on total-evidence data (Winterton and Makarkin 2010), and it was recovered to be the sister group of the latter two fossil genera, suggesting that *Rapisma* might have originated no later than the Early Cretaceous. However, the interspecific relationships among the *Rapisma* species are barely known. Third, considering biology, the knowledge on life history of *Rapisma* is very scarce. It is also interesting to investigate whether the remarkable sexual dimorphism on body and wing coloration (currently found only in a Chinese species *Rapisma xizangense* Yang, 1993) is a common phenomenon in the whole genus.

Rapisma was found from China for the first time in a few years after the aforementioned series of taxonomic works (Yang 1993). Four species were originally described as new species in Yang (1993) from China, namely *Rapisma daianum* Yang, 1993 from Yunnan, *Rapisma yanhuangi* Yang, 1993 from Sichuan, *Rapisma xizangense* Yang, 1993 from Xizang, and *Rapisma zayuanum* Yang, 1993 from Xizang, while one of them (*R. zayuanum*) was synonymized with another sympatrically distributed species (i.e. *R. xizangense*) by Wang et al. (2013) through molecular identification.

In this paper we present a taxonomic revision of *Rapisma* from China, providing descriptions or re-descriptions of all Chinese *Rapisma* species, including two new species. The new species *Rapisma changqingensis* sp. n. from Qinling Mountains extends the northernmost border of the distribution range of *Rapisma* to the transitional zone between eastern Palaearctic and Oriental regions. A revised interpretation on the homologies of genital sclerites of *Rapisma* is also provided.

Material and methods

Specimens for the present study are deposited in the Entomological Museum, China Agricultural University (CAU), Beijing, China; the Institute of Zoology, Chinese Academy of Sciences (IZCAS), Beijing, China; and the Shanghai Entomological Museum, Chinese Academy of Sciences (SEMCAS), Shanghai, China.

Genitalic preparations were made by clearing the apex of the abdomen in a warm, saturated KOH solution for 20–30 min. After rinsing the KOH with acetic acid and water, the apex of the abdomen was transferred to glycerin for further dissection and examination. Habitus photos of adults were taken by using Nikon D800 digital camera with Nikon MICRO NIKKOR 105 mm lens, and the genitalic figures were made by hand drawing under Carl Zeiss Discovery V12 stereo microscope. The terminology of the genitalia generally follows Aspöck and Aspöck (2008).

Results

Genus *Rapisma* McLachlan, 1866

Rapisma McLachlan, 1866: 353. Type species: *Hemerobius viridipennis* Walker, 1853: 276 (original designation).

Generic characters. Medium- to large-sized lacewings (forewing length 19–35 mm). Head (Figs 1–3) partially retracted under prothorax; vertex moderately domed, medially with trace of ecdysial line; clypeus prominent, nearly rectangular. Antennae moniliform, but sometimes subserrate, much shorter than wings (4–11 mm). Compound eyes globular, maximum eye diameter divided by minimum interocular distance (i.e. EI ratio) 0.7–1.1; ocelli absent. Mouthparts mandibulate, mandibles short and broad, margin of labrum excised medially.

Thorax (Fig. 1) stout, covered with fine hairs, prothorax very broad and shield-like. Legs densely setose; tibial spurs absent; length of tarsal segments in approximate ratio 1.0 (basal):0.4:0.35:0.25:0.85 (distal); pretarsal claws broad at base with slight projection on inner side; pretarsus lacking arolium.

Wings (Figs 1–3) broad, with numerous setae on wing margins and veins. Both fore- and hindwing with single nygma between bases of RP+MA and MP, but with trichosors poorly developed, only confined on forewing costal margin.

Forewing broad, greenish, yellowish or brownish. Costal space very broad, particularly at base; costal crossveins usually with marginal forks and with interlink veinlets, most of which are arranged into a longitudinal line on proximal half. Recurrent humeral veinlet present, with several branches. ScA present, short. ScP running free to wing margin, not fused with RA, distally with a few short branches. Subcostal space with many crossveins (number ranging 18–31). RP+MA diverging very near base of R; RP with 3–9 pectinate branches. MA diverging near base of RP and forking repeatedly, with initial branching point either near base of MA or rather distad midpoint of MA. MP diverging into MP1 and MP2 near base; MP1 only forked near wing margin; MP2 profusely and usually dichotomously branched. Cu diverging into CuA and CuP slightly proximad initial branching point of MP. CuA forked only distally; CuP at least initially forked around midpoint; a series of interlink veins present among cua-cup crossveins and longitudinally arranged into a pseudo longitudinal vein. A1 with a few distal branches; A2 and A3 proximally fused, each forked near its base. Simple jugal vein present. Crossvenation exceptionally rich, distal-most crossveins among branches of RP+MA arranged into a gradate series.

Hindwing slightly shorter and narrower than forewing. Frenulum present, short. Venation generally similar to that of forewing, except for the followings. Costal space much narrower than that of forewing, with interlink veinlets among costal crossveins absent. RP with 2–7 pectinate branches. No interlink veinlets among cua-cup crossveins.

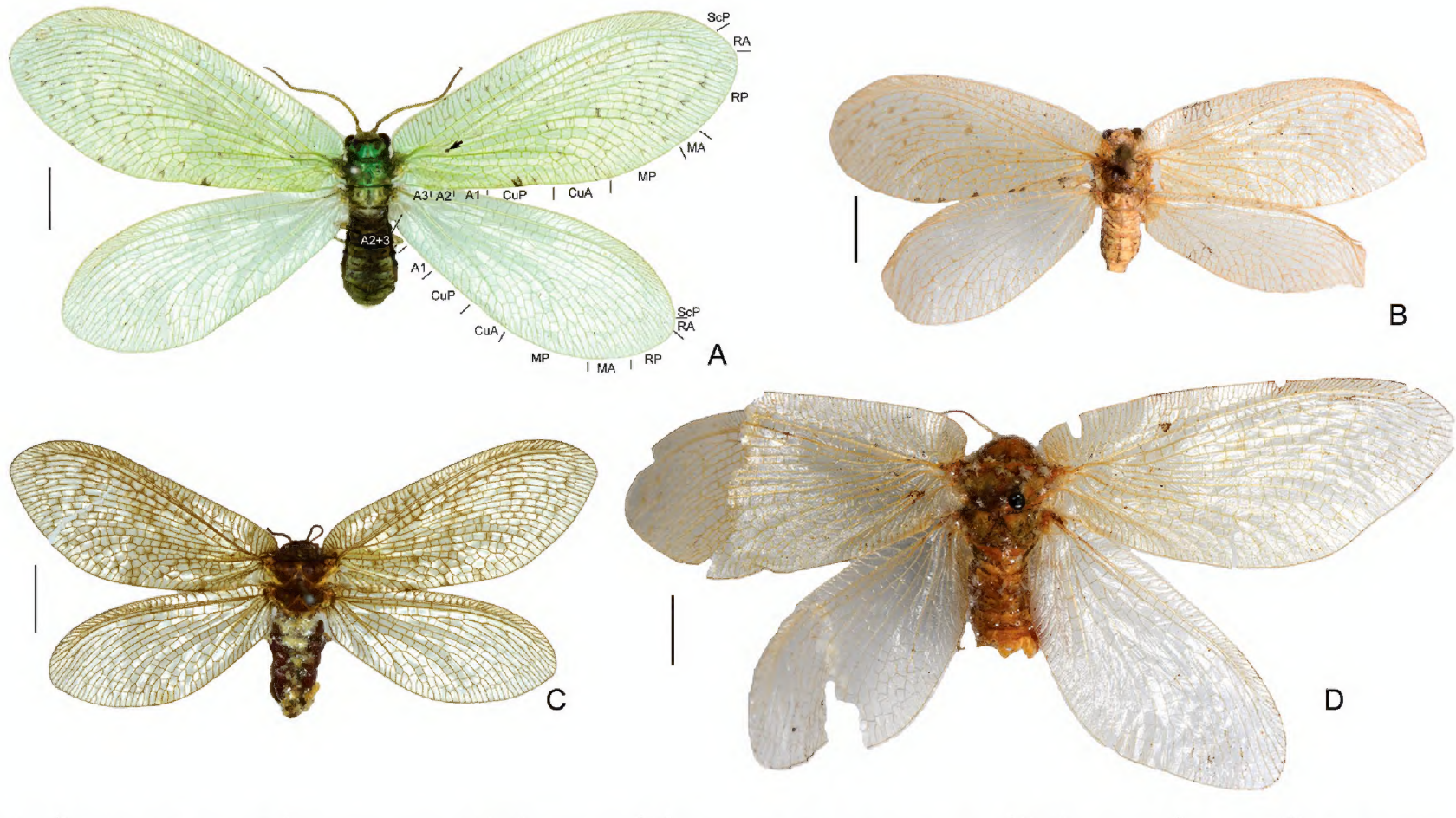

Figure 1. Habitus photos of *Rapisma* spp., (**A**) *Rapisma chikuni* sp. n., holotype male; (**B**) *Rapisma daianum* Yang, holotype male; (**C**) *Rapisma xizangense* Yang, male; (**D**) same species, female (holotype of *Rapisma zayuanum* Yang). Arrow indicates nygma. Scale bar: 5.0 mm.

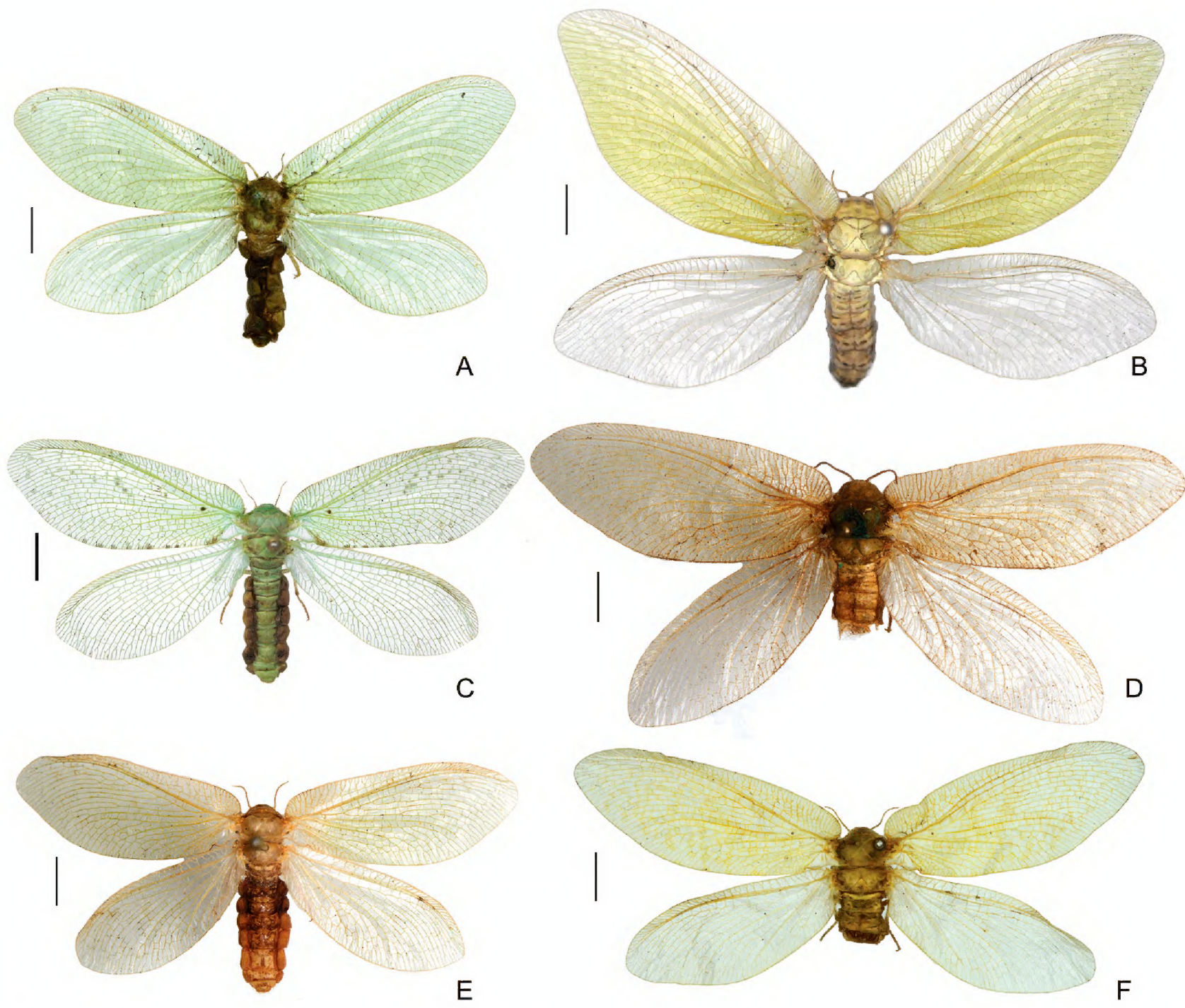

Figure 2. Habitus photos of *Rapisma* spp., (**A**) *Rapisma changqingensis* sp. n., holotype male; (**B**) same species, paratype female; (**C**) *Rapisma yanhuangi* Yang, male; (**D**) same species, holotype female; (**E**) same species, male, lacking forewing dark markings; (**F**) same species, female. Scale bar: 5.0 mm.

Abdomen corpulent. Genital segments much smaller than pregenital segment. Male genitalia (Figs 4–6): Tergum 9 much wider than long; sternum 9 slightly shorter than tergum 9; ectoprocts unpaired in dorsal view; callus cerci present; gonocoxites 9, gonostyli 11 and gonocoxites 11 associated into a complex structure; gonocoxites 9 paired, each of them with a broad lobe (glabrous or covered with many short spines) and a narrow lateral arm, which is articulating laterally on ends of fused gonocoxites 11 (= gonarcus); fused gonocoxites 11 present as a variously shaped arc; gonostyli 11 (= mediuncus lobes) present near posteromedian portion of fused gonocoxites 11, fused, but often showing paired trace, more or less setose; hypandrium internum usually present, but often small and difficult to been found. Female genitalia (Fig. 6): Sternum 7 large; segment 8 much shorter than and slightly retracted in sternum 7, tergum 8 enclosing spiracle; gonocoxites + gonapophyses 8 (= subgenital plate) fused, but usually divided by a transverse suture, posteriorly produced and notched at tip; tergum 9 much shorter than tergum 8, slightly narrowed ventrolaterally; gonocoxites 9 (= ovipositor) rather short and small, valvate, distally with tiny gonostyli 9; a pair of small setose lobes (gonapophyses 9) present posteriad gonocoxites 8 and usually beneath gonocoxites 9; ectoprocts unpaired in dorsal view, laterally with callus cerci; bursa copulatrix medially with a straight channel, anteriorly connected with spermatheca, which constitutes two tubes terminated with a large and a small ovoid sac.

Distribution. China, India, Indonesia, Malaysia, Myanmar, Nepal, Thailand.

Key to *Rapisma* species from China

1 Antennae extremely short, less than 1/5× forewing, moniliform; male gonocoxites 9 glabrous, not bilobed posteroventrally (Figs 6D, 8E, 9E) 2
– Antennae relatively long, ~1/3× forewing length, subserrate; male gonocoxites 9 bilobed and covered with many short spines posteroventrally (Figs 4E, 5) 4
2 Body and forewings brownish in male but greenish in female; male fused gonocoxites 11 in dorsal view distinctly produced posterolaterally (Fig. 6C); Xizang ..... *R. xizangense* Yang
– Body and forewings greenish in both male and female; male fused gonocoxites 11 in dorsal view not produced posterolaterally (Figs 8E, 9E) 3
3 Male head medially without dark marking (Fig. 3E); male fused gonocoxites 11 anteriorly broadly concaved and with a semicircular median notch (Fig. 8C); male gonostyli 11 not prominent posterolaterally (Fig. 8D); female gonocoxites+gonapophyses 8 subtrapezoid, with indistinct transverse suture (Fig. 8H); Shaanxi ..... *R. changqingensis* sp. n.
– Male head medially with dark markings (Fig. 3G); male fused gonocoxites 11 with broadly subtrapezoid anterior incision, but without accessory median notch (Fig. 9C); male gonostyli 11 prominent posterolaterally (Fig. 9D); female gonocoxites+gonapophysis 8 nearly pentagonal, with distinct, arched, transverse suture (Fig. 9H); Sichuan .... *R. yanhuangi* Yang
4 Male head medially without dark marking (Fig. 3B); male gonocoxites 9 with posteromedian lobes curved anteriad (Fig. 5); southern Yunnan ..... *R. daianum* Yang
– Male head medially with dark markings (Fig. 3A); male gonocoxites 9 with posteromedian lobes not curved anteriad (Fig. 4D); western Yunnan ..... *R. chikuni* sp. n.

Rapisma chikuni sp. n.

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Figs 1, 3, 4, 10

Diagnosis. Body and forewings generally greenish. Forewing with sparse small grayish brown spots. Male head medially with dark markings on vertex and frons. Antenna subserrate, ~1/3× forewing length. Male gonocoxites 9 paired, covered with many short spines; each with a robust lobe, which laterally bears a digitiform projection and dorsally bears a flat accessory lobe, and with a short, arcuately curved lateral arm; fused gonocoxites 11 generally arched, in dorsal view nearly semicircular, anteromedially strongly concaved, leaving a pair of broadly shell-shaped lobes, which bear a pair of acutely tapering accessory lobes on their laterodistal ends; gonostyli 11 fused, subtrapezoidal, bearing short setae, ventrally with a pair of obtuse processes and with a feebly sclerotized median bar.

Description. Male. Body length 14.5 mm; forewing length 26.6 mm, hindwing length 23.0 mm.

Head nearly semiglobular, slightly retracted under prothorax, visible in dorsal view. Head yellowish; a transverse blackish brown band present on anterior portion of vertex; frons also with a transverse blackish brown band. Compound eyes blackish brown; EI ratio 0.84. Antenna subserrate, 8.5 mm long, with 62 flagellomeres; yellowish, but proximal two flagellomeres and those on distal 1/4 of flagellum slightly darker. Mandibles with tips black.

Pro- and mesothorax greenish, but metathorax yellowish; pronotum anteriorly with a pair of subtriangular blackish brown markings, and posterolaterally with a pair

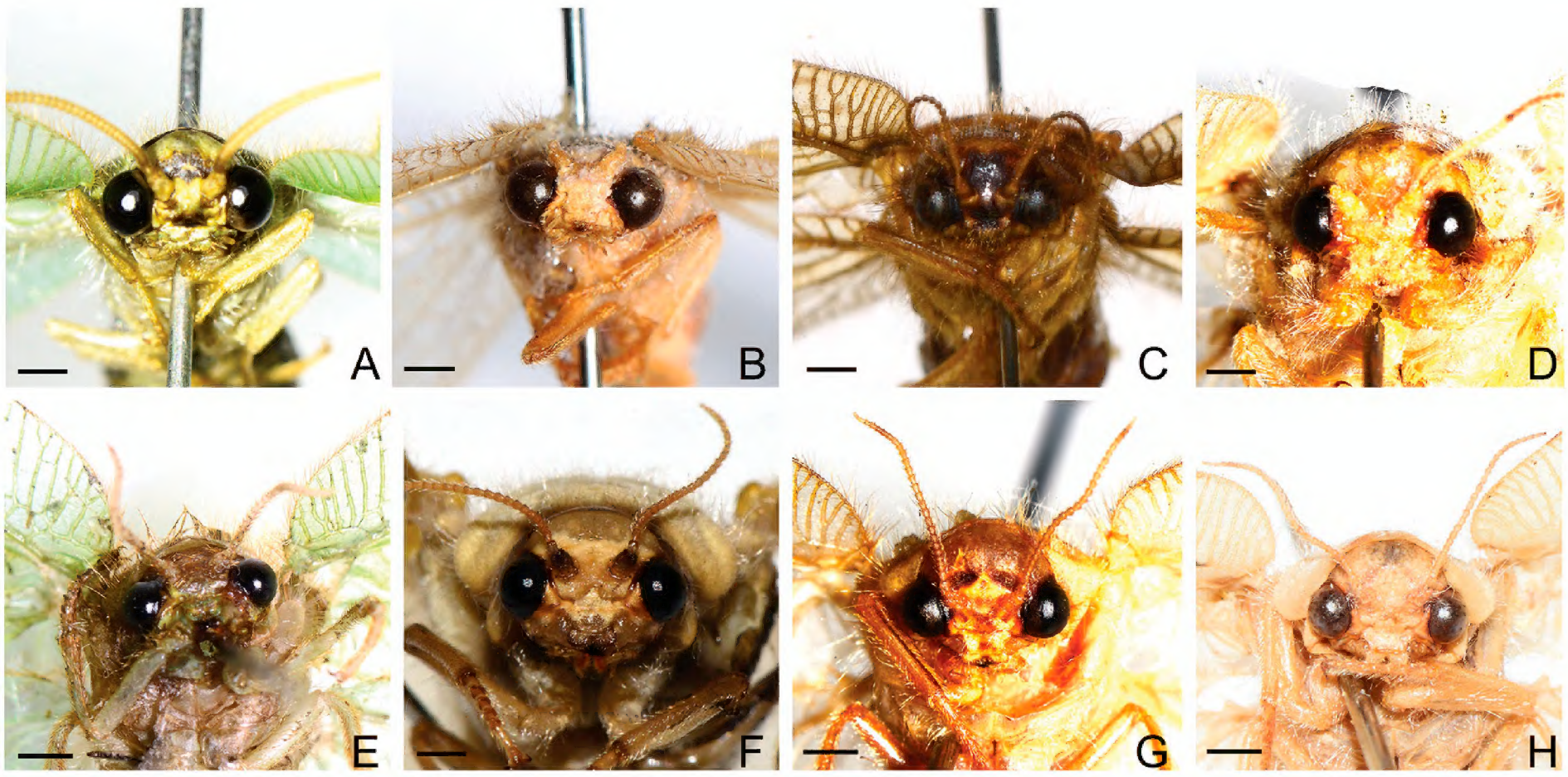

Figure 3. Head of *Rapisma* spp. in frontal view, (**A**) *Rapisma chikuni* sp. n., holotype male; (**B**) *Rapisma daianum* Yang, holotype male; (**C**) *Rapisma xizangense* Yang, male; (**D**) same species, female (holotype of *Rapisma zayuanum* Yang); (**E**) *Rapisma changqingensis* sp. n., holotype male; (**F**) same species, paratype female; (**G**) *Rapisma yanhuangi* Yang, male; (**H**) same species, female. Scale bar: 1.0 mm.

of ovoid blackish brown markings; meso- and metanotum each laterally with a pair of large and a pair of punctiform blackish brown markings. Legs yellowish; pretarsal claws reddish brown, proximally slightly produced.

Forewing greenish, with sparse small grayish brown spots. Trichosors present only along costal margin. A proximal nygma present between RP+MA and MP, blackish, covered with a blackish spot. RP with 7 pectinate branches. Hindwing much paler than forewing, immaculate. A proximal nygma present between RP+MA and MP, yellowish. RP with 4 pectinate branches.

Abdomen brown, with terga and genitalia greenish yellow. Tergum 9 subtrapezoidal, moderately setose. Sternum 9 nearly as long as but narrower than tergum 9, subtrapezoidal, posteriorly slightly concaved. Ectoprocts slightly shorter and much narrower than tergum 9; callus cerci present, slightly prominent. Gonocoxites 9 paired, covered with many short spines; each with a robust lobe, which laterally bears a digitiform projection and dorsally bears a flat accessory lobe, and with a short, arcuately curved lateral arm. Fused gonocoxites 11 generally arched, in dorsal view nearly semicircular, anteromedially strongly concaved, leaving a pair of broadly shell-like lobes, which bear a pair of acutely tapering accessory lobes on their laterodistal ends. Gonostyli 11 fused, subtrapezoidal, bearing short setae, ventrally with a pair of obtuse processes and with a feebly sclerotized median bar. Hypandrium internum relatively large, arrow-shaped, with slenderly foliate lateral lobes.

Female. Unknown.

Material examined. Holotype male, China, Yunnan, Yingjiang, Nabang, Rongshuwang [24°40.48'N, 97°35.33'E], 850 m, 30.VI.2017, Yutang Wang (CAU).

Etymology. The new species is dedicated to Prof. Chikun Yang who made outstanding contributions to the taxonomy of *Rapisma* from China.

Distribution. China (Yunnan).

Remarks. The new species probably belongs to a monophyletic group including *Rapisma corundum* Barnard, 1981 from eastern Myanmar, *Rapisma tamilanum* Barnard, 1981 from southern India, and *R. daianum* from southern Yunnan, China, because these species share some apomorphic characters, e.g. the subserrate male antennae and the posteriorly bilobed male gonocoxites 9. The new species can be distinguished from the related species by the head medially with dark markings, the male gonocoxites 9 with median lobes not curved anteriad, and the male fused gonocoxites 11 broadly shell-like laterally.

Rapisma daianum Yang, 1993

Figs 1, 3, 5, 10

Rapisma daianum Yang, 1993: 147. Type locality: China (Yunnan: Menghai).

Diagnosis. Body and forewings yellowish, possibly greenish in fresh specimens. Forewing with sparse small

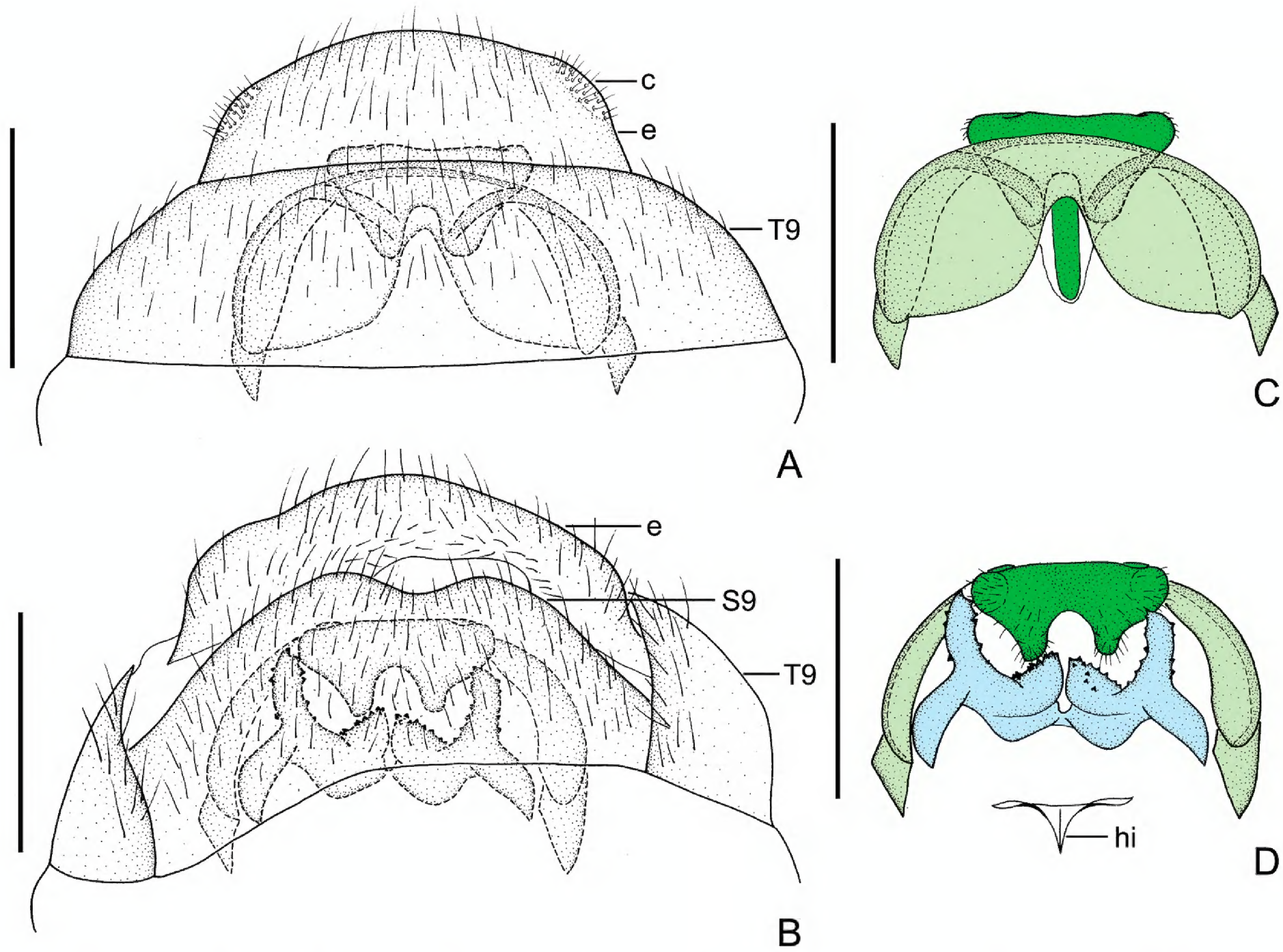

Figure 4. *Rapisma chikuni* sp. n., (**A**) male genitalia, dorsal view; (**B**) male genitalia, ventral view; (**C**) male gonocoxites and gonostyli 11, dorsal view; (**D**) complex of internal male genital sclerites, ventral view. **c** – callus cercus; **e** – ectoproct; **hi** – hypandrium internum; **T** – tergum; **S** – sternum. Gonocoxites 9, gonocoxites 11 and gonostyli 11 are respectively highlighted in pale blue, pale green and green in panels C and D. Scale bar: 1.0 mm.

grayish brown spots. Male head medially without dark marking. Antenna subserrate. Male gonocoxites 9 paired, covered with many short spines; each with a digitiform lobe, which is curved at tip, laterally bears a thick conical projection, and dorsally bears a flat accessory lobe, and with a short, arcuately curved lateral arm; fused gonocoxites 11 generally arched, anteriorly shallowly incised, but anterior margin largely truncate; gonostyli 11 fused, subquadrate, bearing short setae, posteriorly with V-shaped incision, leaving a pair of subtriangular lobes.

Description. Male. Body length 18.0 mm; forewing length 22.0 mm, hindwing length 20.0 mm.

Head nearly semiglobular, slightly retracted under prothorax, visible in dorsal view. Head yellowish, immaculate in general, only with a narrow blackish brown stripe along anterior half of inner margin of compound eye. Compound eyes blackish brown; EI ratio 1.00. Antennae partly damaged, subserrate, yellowish brown to brown, with at least more than 50 antenomeres. Mandibles with tips black.

Thorax yellowish; meso- and metanotum each laterally with a pair of grayish brown markings. Legs yellowish; pretarsal claws reddish brown, proximally slightly produced.

Forewing yellowish, with sparse small grayish brown spots. Trichosors absent. A proximal nygma present between RP+MA and MP, blackish. RP with 6 pectinate branches. Hindwing much paler than forewing, immaculate. A proximal nygma present between RP+MA and MP, yellowish. RP with 3 pectinate branches.

Abdomen yellowish except for pleural portions brown. Gonocoxites 9 paired, covered with many short spines; each with a digitiform lobe, which is curved at tip, laterally bears a thick conical projection, and dorsally bears a flat accessory lobe, and with a short, arcuately curved lateral arm. Gonostyli 11 fused, subquadrate, bearing short setae, posteriorly with V-shaped incision, leaving a pair of subtriangular lobes. Fused gonocoxites 11 generally arched, anteriorly shallowly incised, but anterior margin largely truncate. Hypandrium internum relatively large, arrow-shaped, with slenderly foliate lateral lobes.

Female. Unknown.

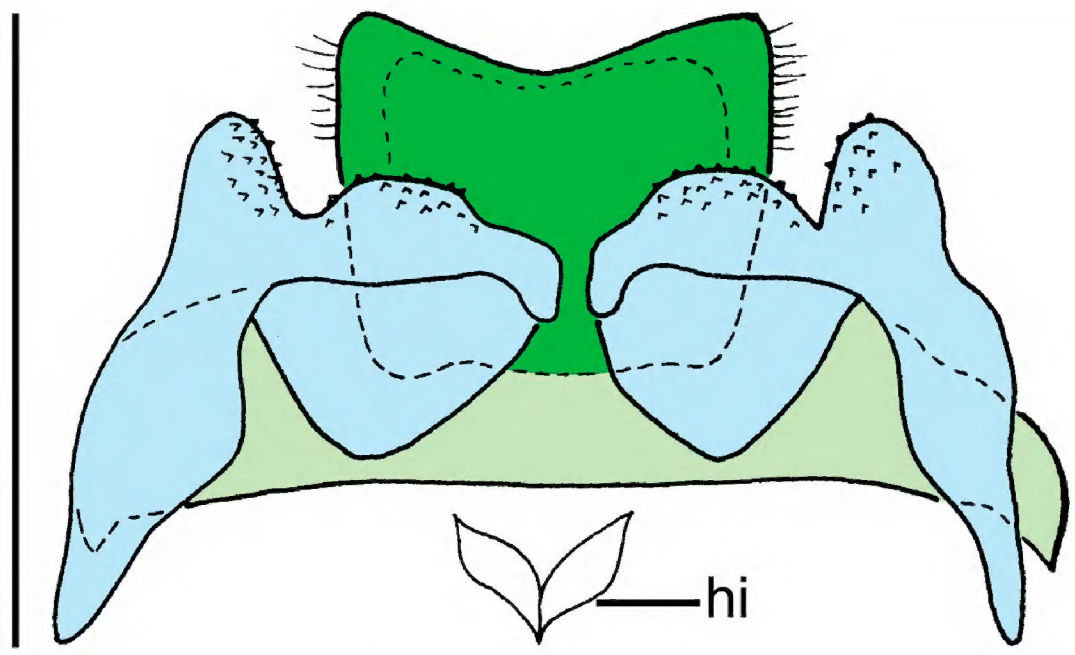

Figure 5. Complex of internal male genital sclerites of *Rapisma daianum* Yang, ventral view. Gonocoxites 9, gonocoxites 11 and gonostyli 11 are respectively highlighted in pale blue, pale green and green. Modified from Yang (1993). Scale bar: 1.0 mm.

Material examined. Holotype male, China, Yunnan, Xishuangbanna, Menghai [ca. 21°57.19'N, 100°27.31'E], 1200–1600 m, 21.VII.1958, Shuyong Wang (IZCAS).

Distribution. China (Yunnan).

Remarks. This species appears to be closely related to *R. corundum* in having similar male gonocoxites 9, while it can be distinguished from the latter species by the forewing with grayish brown spots and the male gonostyli 11 posteriorly with V-shaped incision. In *R. corundum* the forewings are immaculate and the male gonostyli 11 is not incised posteriorly.

Rapisma xizangense Yang, 1993

Figs 2–4, 6, 10

Rapisma xizangense Yang, 1993: 148. Type locality: China (Xizang: Jigong).
Rapisma zayuanum Yang, 1993: 149. Type locality: China (Xizang: Jigong).

Diagnosis. Body and wing coloration greatly differed between males and females, generally brownish in males but greenish in females. Male head medially with dark markings on vertex, frons and clypeus, while female head immaculate. Antenna extremely short, less than 1/5× forewing length. Male gonocoxites 9 paired, glabrous; each with an ovoid lobe, which dorsally bears a subtriangular accessory lobe, and with a slender, arcuately curved lateral arm; fused gonocoxites 11 generally arched, anteriorly shallowly concaved, posteromedially truncate, posterolaterally distinctly produced in dorsal view; gonostyli 11 having subtriangular dorsal lobe with a few short setae, and flat ventral lobe distally with a pair of tufts of long setae.

Description. Male. Body length 13.0–14.0 mm; forewing length 19.0–20.0 mm, hindwing length 16.6–17.0 mm.

Head nearly semiglobular, largely retracted under prothorax, barely visible in dorsal view. Head yellowish brown; a narrow blackish stripe present around compound eye; vertex with a large brown marking, which is sometimes expanded, making vertex almost entirely brown; frons and clypeus medially with a brown marking that is much narrower than vertexal marking. Compound eyes dark brown; EI ratio 0.80. Antennae nearly moniliform, short, 4.4–4.5 mm long, with 27–28 flagellomeres; pale yellowish brown. Mandibles with tips black.

Thorax pale brown, meso- and metathorax slightly paler than prothorax, without any distinct markings. Legs yellowish; pretarsal claws reddish brown, proximally slightly produced.

Forewing brownish, with many small brown spots on crossveins. Trichosors absent. A proximal nygma present between RP+MA and MP, blackish. RP with 8–9 pectinate branches. Hindwing much paler than forewing, immaculate. A proximal nygma present between RP+MA and MP, blackish. RP with 6–8 pectinate branches.

Abdomen brown. Tergum 9 subtrapezoidal, with sparse short setae, posterior margin slightly concaved. Sternum 9 nearly as long as tergum 9, about 1.5 times as wide as long, subtrapezoidal. Ectoprocts nearly as long as tergum 9, ventrally divided into a pair of ovoid lobes; callus cerci present, slightly prominent. Gonocoxites 9 paired, glabrous; each with an ovoid lobe, which dorsally bears a subtriangular accessory lobe, and with a slender, arcuately curved lateral arm. Fused gonocoxites 11 generally arched, anteriorly shallowly concaved, posteromedially truncate, posterolaterally distinctly produced in dorsal view. Gonostyli 11 with a pair of dorsal lobes and a single ventral lobe; dorsal lobe subtriangular, with a few short setae; ventral lobe flat, distally with a pair of tufts of long setae.

Female. Body length 19.1–22.0 mm; forewing length 30.0–31.3 mm, hindwing length 26.0–26.2 mm.

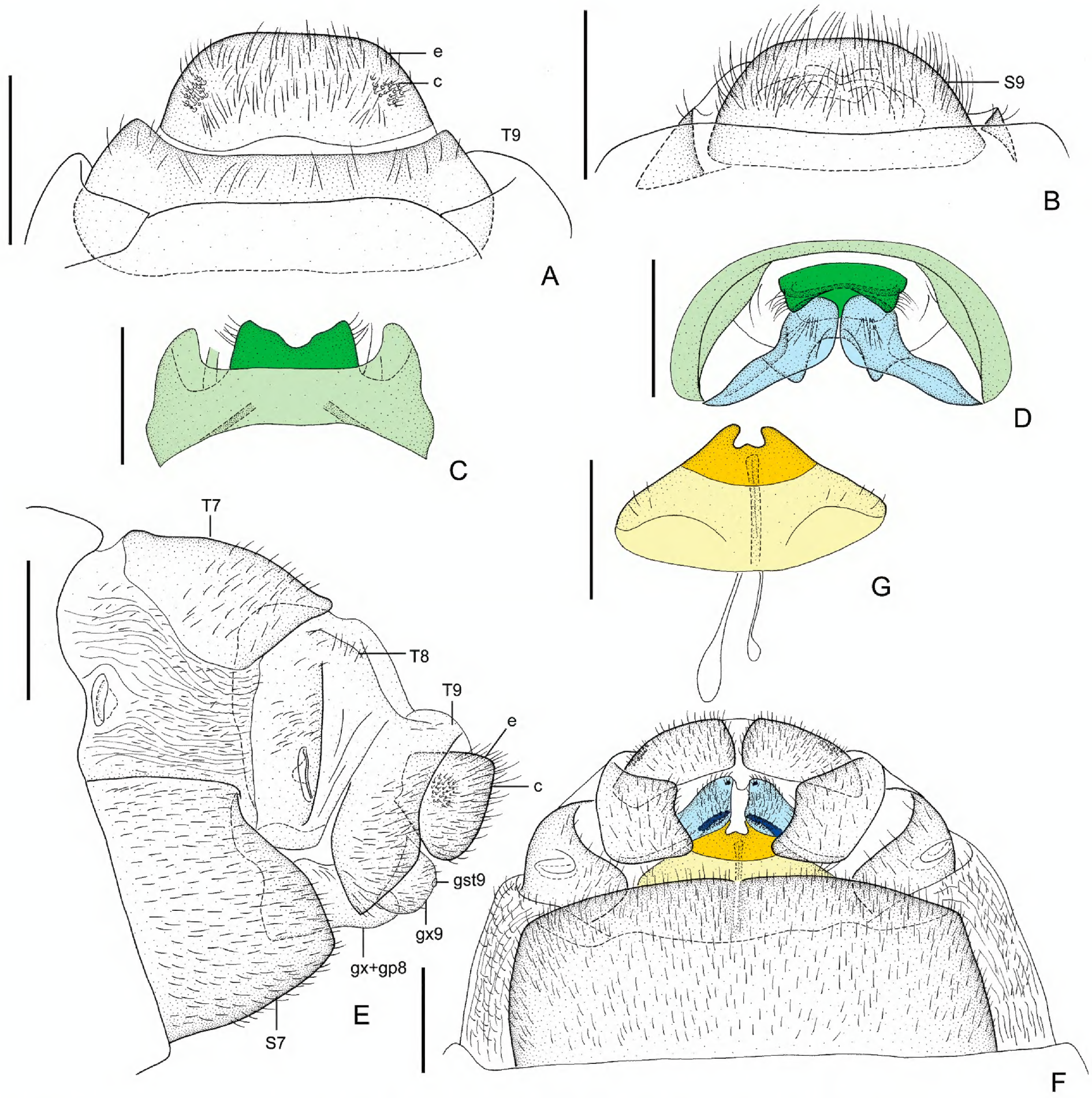

Figure 6. *Rapisma xizangense* Yang, (**A**) male genitalia, dorsal view; (**B**) male genitalia, ventral view; (**C**) male gonocoxites and gonostyli 11, dorsal view; (**D**) complex of internal male genital sclerites, ventral view; (**E**) female genitalia, lateral view; (**F**) female genitalia, ventral view; (**G**) female gonocoxites+gonapophyses 8, ventral view. **c** – callus cercus; **e** – ectoproct; **gx** – gonocoxite; **gp** – gonapophysis; **gst** – gonostylus; **T** – tergum; **S** – sternum. Gonocoxites 9, gonocoxites 11 and gonostyli 11 are respectively highlighted in pale blue, pale green and green in panels C and D. Gonocoxites 9, gonostyli 9 and gonapophyses 9 are respectively highlighted in pale blue, blue, and dark blue in panel F, while gonocoxites 8 and gonapophyses 8 are respectively highlighted in pale yellow and yellow in panels F and G. Scale bar: 1.0 mm (A, B, E, F, G), 0.5 mm (C, D).

Body and forewings in general greenish. Head without dark marking. Forewing sometimes with very indistinct trace of dark spots on a few crossveins.

Sternum 7 large, posteromedially with a narrow groove. Gonocoxites+gonapophyses 8 fused, broadly subtriangular, but divided by an arched transverse suture, notched distally, with a pair of digitiform projections and a weak median projection. Gonocoxites 9 nearly semicircular in lateral view, distally with tiny gonostyli 9; a pair of small setose ovoid gonapophyses 9 present posteriad gonocoxites 8 and beneath gonocoxites 9. Ectoprocts subtrapezoidal in lateral view, slightly broadened posteriad.

Materials examined. Holotype male, China, Xizang, Chayu, Jigong [28°39.17'N, 97°27.21'E], 2300 m, 2.VII.1978, Guangwu Li (IZCAS). 1 female [holotype of *R. zayuanum*], China, Xizang, Chayu, Jigong [28°39.17'N, 97°27.21'E], 2300 m, VIII.1982, Baohai Wang (IZ-

CAS); 1 male, China, Xizang, Chayu [ca. 28°39.17'N, 97°27.21'E], 3.VII.2011, Ye Liu (CAU); 1 female, China, Xizang, Chayu, Shaqiong [ca. 28°39.17'N, 97°27.21'E], 10.VII.2011, Ye Liu (CAU); 1 male, China, Xizang, Chayu [ca. 28°39.17'N, 97°27.21'E], 19.VII.1997, Chaodong Zhu (IZCAS).

Distribution. China (Xizang).

Remarks. This species appears to be closely related to *Rapisma nepalense* Barnard, 1981 from Nepal and *Rapisma almoranum* Barnard, 1981 from northern India in having similar yellowish brown body and medially punctuate head in males as well as male gonocoxite 9 posteriorly with glabrous, ovoid lobe. However, it can be distinguished from *R. nepalense* by the absence of large median dark spot on forewing and the relative broad lobe of male gonocoxite 9, and it differs from *R. almoranum* by the male gonocoxite 9 with a broad lobe and a subtriangular accessory lobe.

Rapisma xizangense is known for the remarkable sexual dimorphism of body and wing coloration (Wang et al. 2013). It may be interesting to figure out whether its related species also have such feature. Barnard (1981) mentioned that *R. almoranum* might be conspecific to *Rapisma viridipenne* (Walker, 1853) from Nepal and northeastern India by having similar forewing marking patterns. So far, *R. viridipenne* is only known from female specimens and its forewing is greenish yellow (Barnard, 1981). If *R. almoranum* and *R. viridipenne* are confirmed to be same species, the sexual dimorphism of body and wing coloration should be also present in this species.

Rapisma changqingensis sp. n.

http://zoobank.org/E7EFEBE1-7CD7-46EF-B57D-DA6D9920C045
Figs 2–3, 7–8, 10

Diagnosis. Body and forewings generally greenish in both males and females. Head medially without dark marking. Antenna extremely short, less than 1/5× forewing length. Male gonocoxites 9 paired, glabrous; each with a broad subtrapezoidal lobe and a slender, arcuately curved lateral arm; fused gonocoxites 11 generally arched, anteriorly broadly concaved but with a semicircular median notch, posteriorly convex in dorsal view; gonostyli 11 having obtuse dorsal lobe with a few short setae, and flat ventral lobe distally with a pair of tufts of long setae.

Description. Male. Body length 18.0 mm; forewing length 25.0 mm, hindwing length 21.7 mm.

Head nearly semiglobular, largely retracted under prothorax, barely visible in dorsal view. Head slightly yellowish green; a narrow blackish stripe present around compound eye and slightly extending toward vertex. Compound eyes blackish brown; EI ratio 0.68. Antenna nearly moniliform, short, 4.0 mm long, with 24 flagellomeres; yellowish throughout. Mandibles with tips black.

Thorax entirely greenish, meso- and metathorax slightly paler than prothorax, without any distinct markings. Legs yellowish throughout; pretarsal claws reddish brown with base yellowish, proximally slightly produced.

Forewing greenish, immaculate. Trichosors absent. A proximal nygma present between RP+MA and MP, whitish. RP with 8 pectinate branches. Hindwing much paler than forewing. A proximal nygma present between RP+MA and MP, whitish. Costal space with a few interlink veinlets among costal crossveins on proximal half. RP with 7 pectinate branches.

Abdomen yellowish green, with terga and genitalia brown. Tergum 9 subtrapezoidal, with sparse short setae. Sternum 9 slightly shorter than tergum 9, about 2.0 times as wide as long, with slightly arcuate posterior margin. Ectoprocts slightly shorter and much narrower than tergum 9, ventrally divided into a pair of ovoid lobes; callus cerci present, slightly prominent. Gonocoxites 9 paired, glabrous; each with a broad subtrapezoidal lobe and a slender, arcuately curved lateral arm. Fused gonocoxites 11 generally arched, anteriorly broadly concaved but with a semicircular median notch, posteriorly convex in dorsal view. Gonostyli 11 with a pair of dorsal and a single ventral lobe; dorsal lobe obtuse, with a few short setae; ventral lobe flat, distally with a pair of tufts of long setae.

Female. Body length 24.8 mm; forewing length 32.0 mm, hindwing length 28.9 mm.

Body and forewings in general greenish. Head without dark marking. Forewing with a few tiny dark spots.

Sternum 7 large, posteromedially with a narrow groove. Gonocoxites+gonapophyses 8 fused, broadly subtrapezoid, notched distally, with a pair of digitiform projections and a weak median projection. Gonocoxites 9 nearly semicircular in lateral view, distally with tiny gonostyli 9; a pair of small setose ovoid gonapophyses 9 present posteriad gonocoxites 8 and beneath gonocoxites 9. Ectoprocts nearly semicircular in lateral view.

Materials examined. Holotype male, China, Shaanxi, Yangxian, Changqing National Nature Reserve, Yangjiagou, 1281 m, 33.6390°N 107.4965°E, 18.VII.2017, Bozun Huang & Zhifei Liu (CAU). Paratype: 1 female, same collecting site as holotype, 24.VII.2017, Puyuan Liu (CAU).

Etymology. The new species is named based on the Changqing National Nature Reserve where type specimens of this species were collected.

Distribution. China (Shaanxi).

Remarks. The new species appears to be closely related to *R. yanhuangi* from Sichuan by the similar body and wing coloration as well as the general characteristics of male genitalia, but it can be distinguished from the latter species by the male head medially without dark marking, the male gonostyli 11 with a pair of dorsal lobes not prominent posterolaterally, and the shape of male fused

Figure 7. Living habitus of *Rapisma changqingensis* sp. n., (**A**) male adult, lateral view; (**B**) female adult, dorsal view.

gonocoxites 11. In *R. yanhuangi* the male head medially possesses several dark markings, the dorsal lobes of male gonostyli 11 are distinctly prominent posterolaterally, and the male fused gonocoxites 11 is differently shaped compared with *R. changqingensis* sp. n.

The two specimens of this new species were collected by accident in a field survey performed by a summer camp for natural education called "Wings of Nature" in Changqing National Nature Reserve, Shaanxi, China. All collectors of these two specimens are middle school

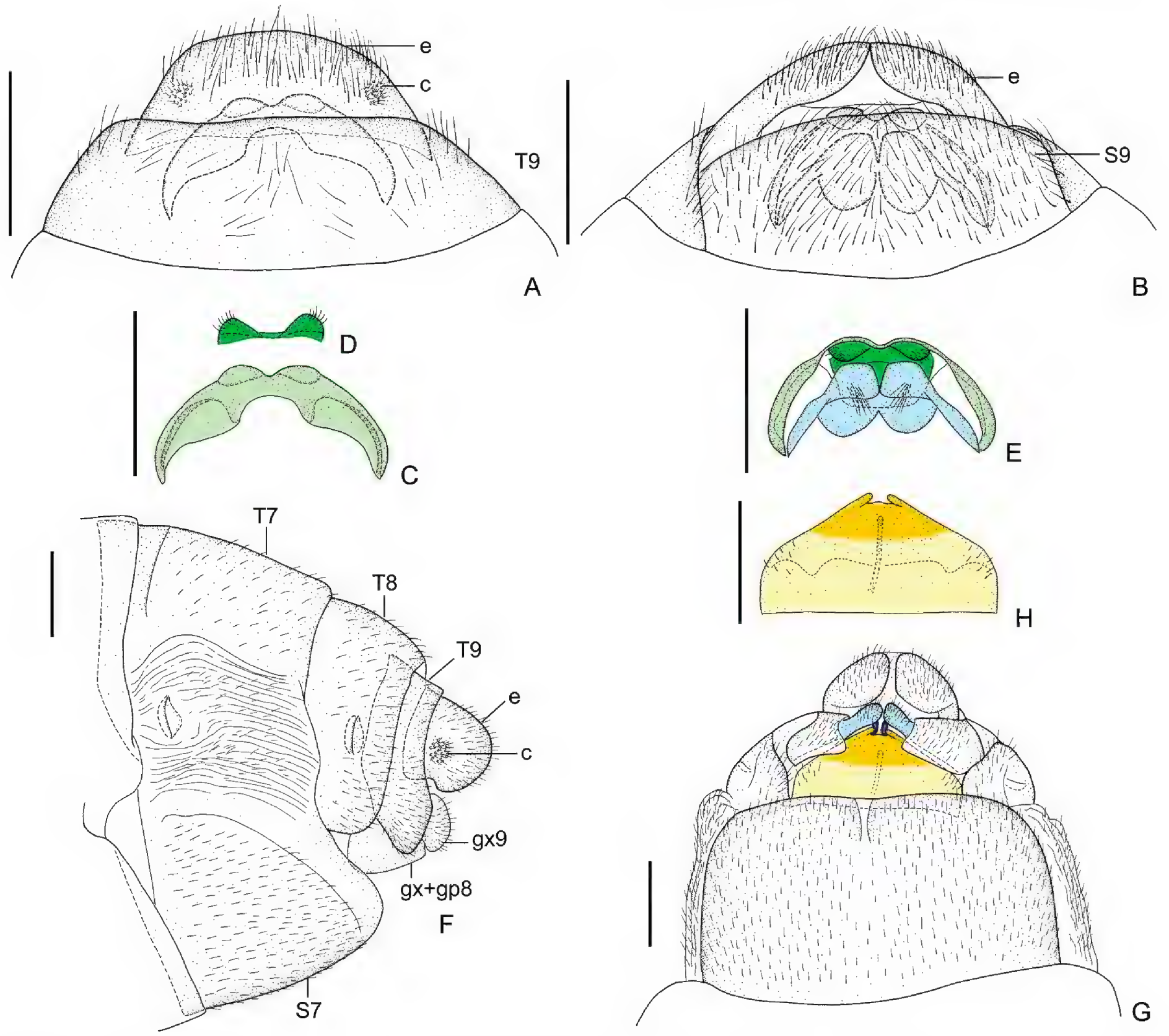

Figure 8. *Rapisma changqingensis* sp. n., (**A**) male genitalia, dorsal view; (**B**) male genitalia, ventral view; (**C**) male gonocoxites 11, dorsal view; (**D**) male gonostyli 11, dorsofrontal view; (**E**) complex of internal male genital sclerites, ventral view; (**F**) female genitalia, lateral view; (**G**) female genitalia, ventral view; (**H**) female gonocoxites+gonapophyses 8, ventral view. **c** – callus cercus; **e** – ectoproct; **gx** – gonocoxite; **gp** – gonapophysis; **T** – tergum; **S** – sternum. Gonocoxites 9, gonocoxites 11 and gonostyli 11 are respectively highlighted in pale blue, pale green and green in panels C–E. Gonocoxites 9 and gonapophyses 9 are respectively highlighted in pale blue and dark blue in panel G (gonostyli 9 present but barely visible in lateral and ventral view), while gonocoxites 8 and gonapophyses 8 are respectively highlighted in pale yellow and yellow in panels G and H. Scale bar: 1.0 mm.

students. The holotype male was found falling in a pond probably from a tree nearby, while the paratype female was found resting on a tree.

The Changqing National Nature Reserve is located at the southern slope of Qinling Mountains, which is commonly considered as a boundary between Palaearctic and Oriental regions in China (Zhang 1999), and it is one of the nature reserves that harbour some endangered wildlife, such as giant pandas, crested ibises, sub-nosed monkeys, etc. The climate of the collecting site of *R. changqingensis* sp. n. is warm temperate, and the vegetation is kind of mixed evergreen broad-leaf and coniferous forest. However, most *Rapisma* species are from subtropical or tropical regions with rainforests. So far, *R. changqingensis* sp. n. represents the northernmost record of *Rapisma*.

Rapisma yanhuangi Yang, 1993

Figs 2–3, 9–10

Rapisma yanhuangi Yang, 1993: 147. Type locality: China (Sichuan: Chongqing).

Diagnosis. Body and forewings generally greenish in both males and females. Head medially with dark mark-

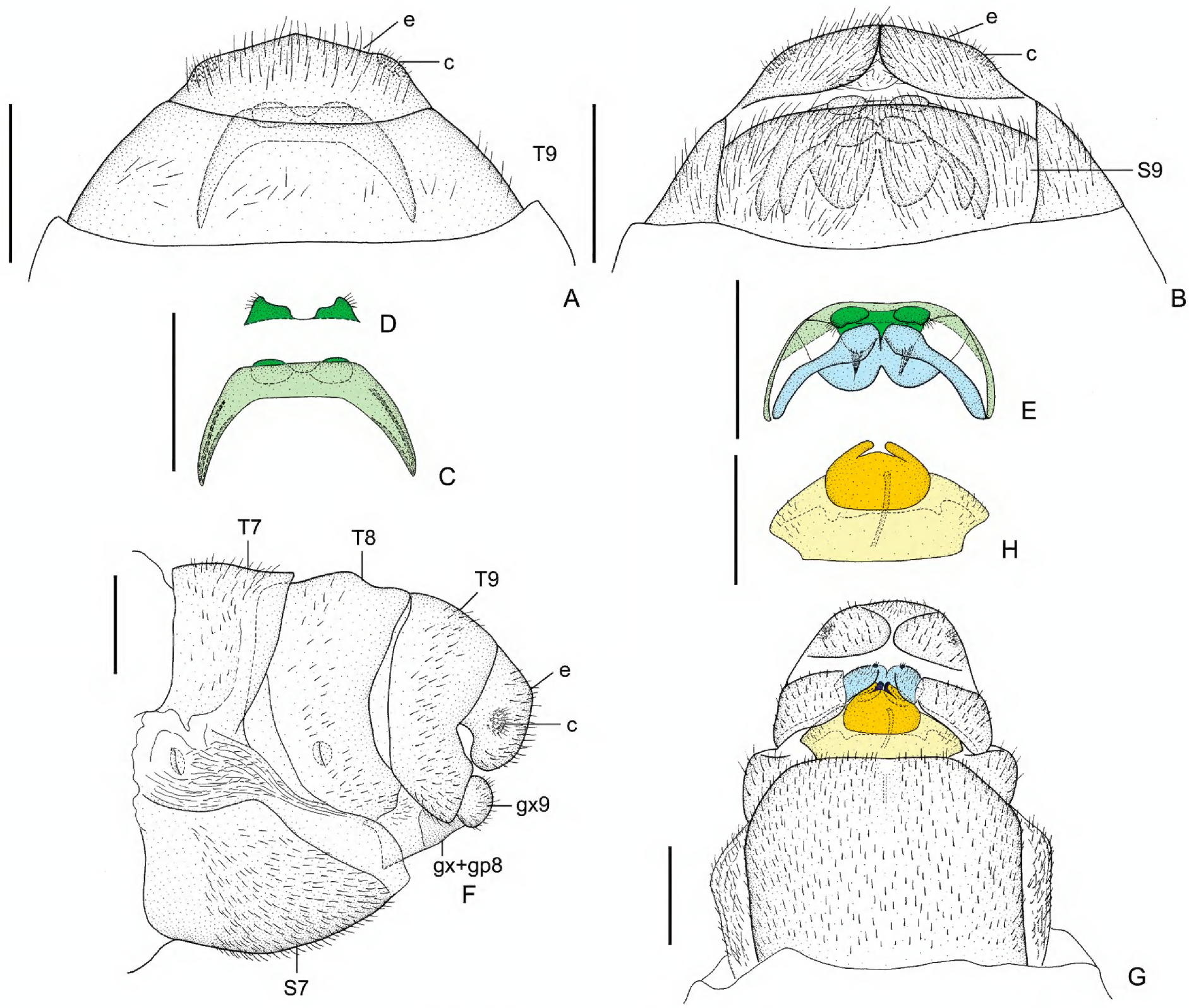

Figure 9. *Rapisma yanhuangi* Yang, (**A**) male genitalia, dorsal view; (**B**) male genitalia, ventral view; (**C**) male gonocoxites 11, dorsal view; (**D**) male gonostyli 11, dorsofrontal view; (**E**) complex of internal male genital sclerites, ventral view; (**F**) female genitalia, lateral view; (**G**) female genitalia, ventral view; (**H**) female gonocoxites+gonapophyses 8, ventral view. **c** – callus cercus; **e** – ectoproct; **gx** – gonocoxite; **gp** – gonapophysis; **gst** – gonostylus; **T** – tergum; **S** – sternum. Gonocoxites 9, gonocoxites 11 and gonostyli 11 are respectively highlighted in pale blue, pale green and green in panels C–E. Gonocoxites 9, gonostyli 9 and gonapophyses 9 are respectively highlighted in pale blue and dark blue in panel G, while gonocoxites 8 and gonapophyses 8 are respectively highlighted in pale yellow and yellow in panels G and H. Scale bar: 1.0 mm.

ings on vertex, frons and clypeus. Antenna extremely short, less than 1/5× forewing length. Male gonocoxites 9 paired, glabrous; each with a broad subtrapezoidal lobe and a slender, arcuately curved lateral arm; fused gonocoxites 11 generally arched, anteriorly with a broad, subtrapezoidal incision, posteriorly truncate, laterally acutely tapering in dorsal view; gonostyli 11 having dorsal lobe posterolaterally distinctly prominent, with a few short setae, and flat ventral lobe distally with a tuft of long setae.

Description. Male. Body length 17.2–20.0 mm; forewing length 20.8–25.8 mm, hindwing length 18.4–22.1 mm.

Head nearly semiglobular, largely retracted under prothorax, barely visible in dorsal view. Head generally pale yellowish green; a narrow blackish stripe present around compound eye; a pair of transverse, ovoid, blackish brown markings present on vertex; several small brownish spots present along midline of frons and clypeus. Compound eyes dark brown; EI ratio 0.78. Antenna nearly moniliform, short, 4.7–4.9 mm long, with 23–26 flagellomeres; pale yellowish brown. Mandibles with tips black.

Thorax entirely greenish, meso- and metathorax slightly paler than prothorax, without any distinct markings. Legs pale yellowish brown, slightly darkened on apices of tibiae and all tarsomeres; pretarsal claws reddish brown, proximally slightly produced.

Forewing greenish, with some small grayish spots on distal half and along posterior margin, but these dark markings sometimes completely reduced. Trichosors absent. A proximal nygma present between RP+MA and

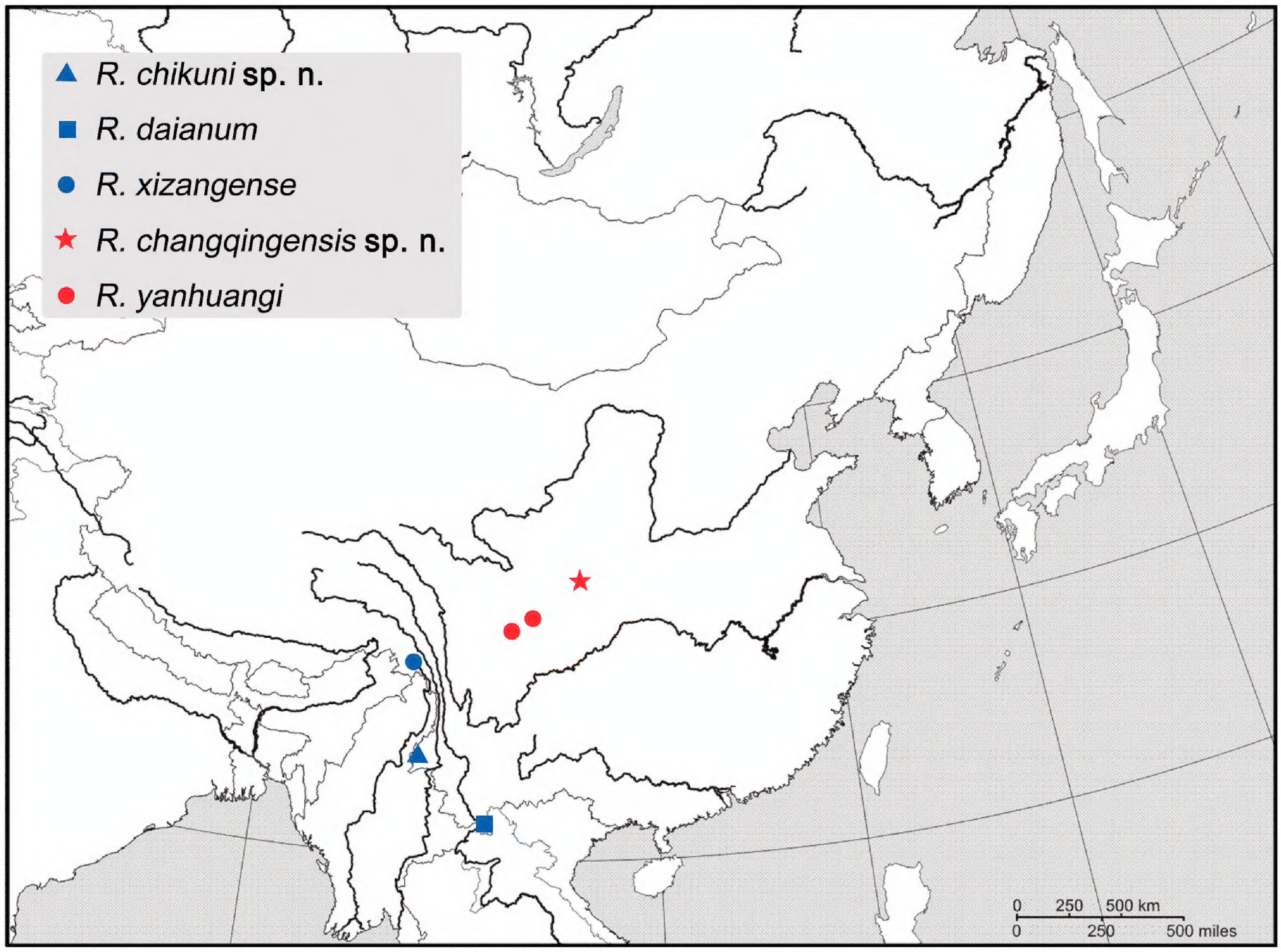

Figure 10. Distribution map of the *Rapisma* species from China.

MP, blackish, sometimes with a distinct black spot. RP with 6–9 pectinate branches. Hindwing much paler than forewing. A proximal nygma present between RP+MA and MP, blackish. RP with 6–7 pectinate branches.

Abdomen yellowish brown, with terga and genitalia greenish. Tergum 9 subtrapezoidal, with sparse short setae. Sternum 9 slightly shorter than tergum 9, about 2.5 times as wide as long, with slightly arcuate posterior margin. Ectoprocts slightly shorter and much narrower than tergum 9, ventrally divided into a pair of ovoid lobes; callus cerci present, slightly prominent. Gonocoxites 9 paired, glabrous; each with a broad subtrapezoidal lobe and a slender, arcuately curved lateral arm. Fused gonocoxites 11 generally arched, anteriorly with a broad, subtrapezoidal incision, posteriorly truncate, laterally acutely tapering in dorsal view. Gonostyli 11 with a pair of dorsal and a pair of ventral lobes; dorsal lobe posterolaterally distinctly prominent, with a few short setae; ventral lobe flat, distally with a tuft of long setae.

Female. Body length 18.0–20.0 mm; forewing length 27.0–27.3 mm, hindwing length 27.0–24.0 mm.

Body and forewings in general greenish. Head slightly darkened on vertex, with or without a dark spot on frons. Forewing without any dark marking.

Sternum 7 large, posteromedially with a narrow groove. Gonocoxites+gonapophyses 8 fused, nearly pentagonal, but divided by an arched transverse suture, notched distally, with a pair of digitiform projections and a weak median projection. Gonocoxites 9 nearly semicircular in lateral view, distally with tiny gonostyli 9; a pair of small setose ovoid gonapophyses 9 present posteriad gonocoxites 8 and beneath gonocoxites 9. Ectoprocts ovoid in lateral view.

Materials examined. Holotype female, China, Sichuan, Chongqing [= Chongzhou, ca. 30°37.29'N, 103°40.13'E], 31.V.1954, Hechang Liu (IZCAS). 4 male 1 female, China, Sichuan, Shimian, Liziping Nature Reserve, Gongyihai Station [29°05.35'N, 102°20.11'E], 2100 m, 22–25. VII.2007, Liu, Zhang, Zhou & Bi (SEMCAS).

Distribution. China (Sichuan).

Remarks. This species was originally described based on a single female specimen (Yang 1993). As the new materials, particularly the female, show almost same characteristics to the holotype female, I identified them to be *R. yanhuangi*. Nevertheless, further confirmation on the present identification should be considered if male specimens from the type locality are found in the future. The new materials of *R. yanhuangi* were collected by light trap. Among the male specimens the greenish forewings possess a few grayish spots or lack any dark spots, while the median dark

spot on frons is present in the holotype female but absent in another female of the new materials. It suggests that identification of *Rapisma* species based solely on head and wing markings must be cautious as these characters are variable among conspecific individuals in some species.

Discussion

Homology of genital sclerites

The genital segments of *Rapisma* are much smaller than the pregenital segments that are rather robust and in dried specimens are sometimes inconspicuous and partly retracted in the preceding pregenital segments. Due to the rareness of *Rapisma* species, very few works deal with the morphology of the genital sclerites of this genus. Barnard (1981) first interpreted the genitalia of *Rapisma* following the homology assessment and terminology proposed by Acker (1960). In this work the male genitalia of *Rapisma* are composed of tergum and sternum 9, tergum 10, paired gonocoxites, gonarcus, mediuncus (including upper mediuncus lobes and lower mediuncus lobes), and hypandrium internum, while the female genitalia constitute terga 8–10, subgenital plate, and paired gonapophyses laterales. It is noteworthy that the female gonostyli of gonapophyses laterales are missing in the illustration of Barnard (1981). However, Yang (1993) illustrated the small gonostyli on the apex of the female ovipositor (= gonapophyses laterales). Aspöck and Aspöck (2008) provided a new homology assessment of the genital sclerites of Neuropterida with revised terminology based on the gonocoxite concept [i.e. the coxopodite concept of Acker (1960) for Neuropterida]. In this work, irrespective of terga and sterna of segments 8–10, the male genital sclerites comprise paired gonocoxites + gonostyli 9 (= gonocoxites), fused gonocoxites and gonostyli 11 (= gonarcus and mediuncus), and hypandrium internum, while the female genital sclerites comprise fused gonocoxites 8 (= subgenital plate) and paired gonocoxites 9 (= gonapophyses laterales). Notably, the sclerites belonging to segment 10 except for ectoprocts are missing in males of *Rapisma*, and the male gonostyli 11 are enlarged, being considered to be a synapomorphy of Ithonidae + Myrmeleontiformia (Aspöck and Aspöck 2008). I basically agree to the homology interpretation for *Rapisma* proposed in Aspöck and Aspöck (2008). Nevertheless, a few amendments are made below.

Concerning the male gonocoxites 9, they are paired, each with a broad lobe and a slender lateral arm, while the broad lobe is modified into two differently shaped parts, i.e. the posteroventral part, being glabrous or covered with many tiny spines, and the anterodorsal part, being flat and broadly ovoid or subtriangular (Figs 4D, 6D). Aspöck and Aspöck (2008) interpreted the former part to be the gonostylus 9 and did not assign the latter part to be a component of segment 9. Compared with the related genera of *Rapisma* (e.g. *Adamsiana*), in which no gonostyli 9 are found in Aspöck and Aspöck (2008), there is no substantial argument to interpret the anterodorsal lobe to be the gonostylus 9. So, here I interpret that only gonocoxites 9, possibly amalgamated with gonapophysis and gonostyli 9 (but unrecognizable), are present in males of *Rapisma*.

Concerning the female genitalia, it should be first confirmed that the gonostyli 9 are present at the apex of gonocoxites 9 in all female *Rapisma* specimens herein examined (Fig. 6F). Probably, they are present in all *Rapisma* species. Nevertheless, they are very small and could be overlooked as in Barnard (1981) and Aspöck and Aspöck (2008). Furthermore, there is a pair of curious small sclerites present beneath anterior portion of gonocoxites 9 (see Yang 1993: fig. 1; Fig. 6F). They should represent the gonapophyses 9 as similar sclerites are interpreted as gonapophyses 9 in the ithonid genus *Polystoechotes* (see Aspöck and Aspöck 2008: fig. 134). In addition, the fused gonocoxites 8 of *Rapisma* interpreted in Aspöck and Aspöck (2008) is divided anteroposteriorly by a transverse suture (Fig. 6G), and the posterior part is herein considered to be the fused gonapophyses 9, being similar to that in *Polystoechotes* (see Aspöck and Aspöck, 2008: fig. 135).

In general, the genital sclerites of *Rapisma* retain more plesiomorphic features in comparison to other ithonid genera with exceptionally enlarged male ectoprocts, highly specialized female gonocoxites 9, reduced male gonostyli 11, reduced female gonostyli 9, etc. The configuration of male gonocoxites 9 and gonostyli 11 in *Rapisma* is unique among the genera of Ithonidae and may be attributed to the autapomorphies of this genus.

Phylogenetic positions of Chinese *Rapisma*

So far there is no phylogenetic analysis concerning the relationships among *Rapisma* species. Only in Barnard (1981) seven characters were outlined and used to infer the interspecific relationships of this genus, i.e. the presence/absence of dark transverse band on head, the presence/absence of central projection on female gonapophyses 8, the glabrous/spinous male gonocoxites 9, the relatively short/long antennae, the relatively large/small compound eyes, the subserrate/moniliform antennae, and the posteriorly bilobed/undivided male gonocoxites 9 (the former state considered as apomorphic). At present I feel refrain to perform any phylogenetic analysis because there are still a few species with males or females unknown and because the male genitalia of those species from other countries need further examinations given more phylogenetically informative characters could be found. Nevertheless, two groups of species proposed by Barnard (1981) could be justified as they possess some unique apomorphic characters.

First, three species distributed along the southern Himalayas, namely *R. viridipenne*, *R. nepalense*, and *R. almoranum*, form a group based on the glabrous male gonocoxites 9 and the short antennae [*Rapisma burmanum* Navás, 1929 that was originally placed in this group by Barnard (1981) was subsequently removed due to the presence of spinous male gonocoxites 9 (Barnard 1986)]. Thus, three Chinese species, i.e. *R. xizangense*, *R. changqingensis* sp. n., and *R. yanhuangi*, probably belong

to this species group by having the aforementioned apomorphic characters. Within this group, *R. changqingensis* sp. n. and *R. yanhuangi* might form a subgroup because of similar body and wing coloration (both male and female generally greenish) and similarly shaped male gonocoxites 9. The distribution areas of these two closely related species are also near to each other, located at the northeastern edge of Hengduan Mountains and southwestern edge of Qinling Mountains (Fig. 10). Interestingly, these areas are overlapped with the distribution range of giant pandas. The divergence between these two species might be in correlated to geographical isolation formed by certain mountains from these areas. Likewise, given similar range along Himalayas, *R. xizangense* may have close affinity with the other three Himalayan *Rapisma* species, but no definite apomorphy supporting this hypothesis has yet been found.

Second, *R. corundum* from eastern Myanmar and *R. tamilanum* from southern India are considered to form a monophyletic group by the subserrate male antennae and the posteriorly bilobed male gonocoxites 9 (Barnard 1981). Two Chinese species from Yunnan, i.e. *R. chikuni* sp. n. and *R. daianum*, should belong to this species group by having same apomorphic characters.

Most of the other *Rapisma* species are considered to form a group called the *Rapisma malayanum*-complex, which are mainly distributed in western Malaysia but also in Java and Myanmar (Barnard and New 1985, 1986). However, there is no distinct apomorphic character proposed to support the monophyly of this group. From China no species related to this group has yet been found.

Conclusions

This study summarized the present knowledge on the ithonid genus *Rapisma* from China, currently with five species that respectively belong to two monophyletic species group. The morphology of the genitalia of this genus was also further understood. In addition, the distribution region of *Rapisma* is now known to reach the border between Palaearctic and Oriental regions.

Rapisma is the only extant genus of Ithonidae from Asia. The phylogenetic status of this genus in Ithonidae, as well as the phylogenetic relationships among species within the genus, is of high interest and significance for understanding the origin and diversification pattern of the genus. A dated phylogeny of Ithonidae and *Rapisma* as well stand as a key to figure out the above questions, while comprehensive sampling, particularly new materials for molecular works, is required.

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References

Acker TS (1960) The comparative morphology of the male terminalia of Neuroptera (Insecta). Microentomology 24: 25–84.

Aspöck U, Aspöck H (2008) Phylogenetic relevance of the genital sclerites of Neuropterida (Insecta: Holometabola). Systematic Entomology 33: 97–127. https://doi.org/10.1111/j.1365-3113.2007.00396.x

Barnard PC (1981) The Rapismatidae (Neuroptera): montane lacewings of the oriental region. Systematic Entomology 6: 121–136. https://doi.org/10.1111/j.1365-3113.1981.tb00430.x

Barnard PC, New TR (1985) New species in the *Rapisma malayanum*-complex (Neuroptera: Rapismatidae). Neuroptera International 3: 165–173.

Barnard PC, New TR (1986) The male of *Rapisma burmanum* Navás (Neuroptera: Rapismatidae). Neuroptera International 4: 125–127.

Krüger L (1922) Hemerobiidae. Beiträge zu einer Monographie der Neuropteren-Familie der Hemerobiiden. Stettiner Entomologische Zeitung 83: 138–172.

McLachlan R (1866) A new genus of Hemerobidae, and a new genus of Perlidae. Transactions of the Entomological Society of London 15: 353–354. https://doi.org/10.1111/j.1365-2311.1967.tb01441.x

Navás L (1929) Insectos exóticos Neurópteros y afines del Museo Civico de Génova. Annali del Museo Civico di Storia Naturale Giacomo Doria 53: 354–389.

New TR (1985) A new species of Rapismatidae (Neuroptera) from Sabah. Neuroptera International 3: 133–135.

Oswald JD (2017) Neuropterida Species of the World. Version 5.0. http://lacewing.tamu.edu/SpeciesCatalog/Main.

Walker F (1853) Catalogue of the specimens of neuropterous insects in the collection of the British Museum. Part II (Sialides–Nemopterides). Newman, London, 193–476.

Wang YY, Liu XY, Winterton SL, Yan Y, Chang W, Yang D (2013) Comparative mitogenomic analysis reveals sexual dimorphism in a rare montane lacewing (Insecta: Neuroptera: Ithonidae). PLoS ONE 8: e83986. https://doi.org/10.1371/journal.pone.0083986

Winterton SL, Makarkin VN (2010) Phylogeny of moth lacewings and giant lacewings (Neuroptera: Ithonidae, Polystoechotidae) using DNA sequence data, morphology, and fossils. Annals of the Entomological Society of America 103: 511–522. https://doi.org/10.1603/AN10026

Yang CK (1993) The montane lacewings (Neuroptera: Rapismatidae) new to China, with descriptions of four new species. Scientific Treatise on Systematic and Evolutionary Zoology 2: 145–153.

Zhang YZ (1999) Zoogeography of China. Science Press, Beijing, 502 pp.